

# Flaring radio lanterns along the ridge line: Long-term oscillatory motion in the jet of S5 1803 + 784

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## Abstract

© 2018 The Author(s) Published by Oxford University Press on behalf of the Royal Astronomical Society. We present a detailed analysis of 30 very long baseline interferometric (VLBI) observations of the BL Lac object S5 1803+784 ( $z=0.679$ ), obtained between mean observational time 1994.67 and 2012.91 at observational frequency 15 GHz. The long-term behaviour of the jet ridge line reveals the jet experiences an oscillatory motion superposed on its helical jet kinematics on a time-scale of about 6 yr. The excess variance of the positional variability indicates the jet components being farther from the VLBI core have larger amplitude in their position variations. The fractional variability amplitude shows slight changes in 3 yr bins of the component's position. The temporal variability in the Doppler boosting of the ridge line results in jet regions behaving as flaring 'radio lanterns'. We offer a qualitative scenario leading to the oscillation of the jet ridge line that utilizes the orbital motion of the jet emitter black hole due to a binary black hole companion. A correlation analysis implies composite origin of the flux variability of the jet components, emerging due to possibly both the evolving jet structure and its intrinsic variability.

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## Keywords

BL Lacertae objects: Individual: S5 1803+784, Galaxies: Active, Radio continuum: Galaxies, Techniques: Interferometric

## References

- [1] Begelman M. C., Blandford R. D., Rees M. J., 1980, *Nature*, 287, 307
- [2] Blandford R. D., Znajek R. L., 1977, *MNRAS*, 179, 433
- [3] Britzen S., Roland J., Laskar J., Kokkotas K., Campbell R. M., Witzel A., 2001, *A&A*, 374, 784
- [4] Britzen S. et al., 2005a, *A&A*, 444, 443
- [5] Britzen S., Witzel A., Krichbaum T. P., Beckert T., Campbell R. M., Schalinski C., Campbell J., 2005b, *MNRAS*, 362, 966
- [6] Britzen S. et al., 2007, *A&A*, 472, 763
- [7] Britzen S. et al., 2008, *A&A*, 484, 119
- [8] Britzen S. et al., 2010, *A&A*, 511, A57 (B2010)
- [9] Camenzind M., Krockenberger M., 1992, *A&A*, 255, 59
- [10] Cawthorne T. V., Jorstad S. G., Marscher A. P., 2013, *ApJ*, 772, 14
- [11] Condon J. J., Condon M. A., Gisler G., Puschell J. J., 1982, *ApJ*, 252, 102

- [12] Edelson R. A., Krolik J. H., Pike G. F., 1990, *ApJ*, 359, 86
- [13] Edelson R., Turner T. J., Pounds K., Vaughan S., Markowitz A., Marshall H., Dobbie P., Warwick R., 2002, *ApJ*, 568, 610
- [14] Gergely L. Á., Biermann P. L., 2009, *ApJ*, 697, 1621
- [15] Gold R., McKinney J., Johnson M., Doeleman S., Event Horizon Telescope Collaboration, 2016, in Voss D., ed., *APS Meeting Abstracts*, AIP, College Park, MD
- [16] Hardee P. E., 1987, *AJ*, 318, 78
- [17] Hovatta T., Valtaoja E., Tornikoski M., Lähteenmäki A., 2009, *A&A*, 494, 527
- [18] Hummel C. A., Muxlow T. W. B., Krichbaum T. P., Quirrenbach A., Schalinski C. J., Witzel A., Johnston K. J., 1992, *A&A*, 266, 93
- [19] Jorstad S. G. et al., 2005, *AJ*, 130, 1418
- [20] Karouzos M., Britzen S., Witzel A., Zensus A. J., Eckart A., 2012a, *AN*, 333, 417
- [21] Karouzos M., Britzen S., Witzel A., Zensus J. A., Eckart A., 2012b, *A&A*, 537, A112
- [22] Kelly B. C., Hughes P. A., Aller H. D., Aller M. F., 2003, *ApJ*, 591, 695
- [23] Kun E., Gabañyi K. É., Karouzos M., Britzen S., Gergely L. Á., 2014, *MNRAS*, 445, 1370
- [24] Kun E., Frey S., Gabañyi K. É., Britzen S., Cseh D., Gergely L. Á., 2015, *MNRAS*, 454, 1290
- [25] Lawrence C. R., Zucker J. R., Readhead A. C. S., Unwin S. C., Pearson T. J., Xu W., 1996, *ApJS*, 107, 541
- [26] Lister M. L. et al., 2009, *AJ*, 138, 1874
- [27] Lister M. L. et al., 2013, *AJ*, 146, 120
- [28] Marscher A. P., Gear W. K., 1985, *ApJ*, 298, 114
- [29] Nandra K., George I. M., Mushotzky R. F., Turner T. J., Yaqoob T., 1997, *ApJ*, 476, 70
- [30] Planck Collaboration XIII, 2016, *A&A*, 594, A13
- [31] Pollack L. K., Taylor G. B., Zavala R. T., 2003, *ApJ*, 589, 733
- [32] Readhead A. C. S., 1994, *ApJ*, 426, 51
- [33] Rodríguez-Pascual P. M. et al., 1997, *ApJS*, 110, 9
- [34] Roland J., Britzen S., Kudryavtseva N. A., Witzel A., Karouzos M., 2008, *A&A*, 483, 125
- [35] Roos N., Kaastra J. S., Hummel C. A., 1993, *ApJ*, 409, 130
- [36] Sbarrato T., Ghisellini G., Maraschi L., Colpi M., 2012, *MNRAS*, 421, 1764
- [37] Shepherd M. C., Pearson T. J., Taylor G. B., 1994, *BAAS*, 26, 987
- [38] Steffen W., Krichbaum T. P., Britzen S., Witzel A., 1995a, in Green D. A., Steffen W., eds, *The XXVIIth Young European Radio Astronomers Conference*, MRAO, Cambridge, p. 29
- [39] Steffen W., Zensus J. A., Krichbaum T. P., Witzel A., Qian S. J., 1995b, *A&A*, 302, 335
- [40] Tateyama C. E., Kingham K. A., Kaufmann P., de Lucena A. M. P., 2002, *ApJ*, 573, 496
- [41] Vaughan S., Edelson R., Warwick R. S., Uttley P., 2003, *MNRAS*, 345, 1271
- [42] Vermeulen R. C., Britzen S., Taylor G. B., Pearson T. J., Readhead A. C. S., Wilkinson P. N., Browne I. W. A., 2003, in Zensus J. A., Cohen M. H., Ros E., eds, *ASP Conf. Ser. Vol. 300, Radio Astronomy at the Fringe*. Astron. Soc. Pac., San Francisco, p. 43